



EEC2146: Electronic Circuits and Measurements

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EEC2146: Electronic Circuits and Measurements

schedule of Classes

- **Lectures:**
- Wednesday 8:30 pm to 11:30 in Room 11.
- **Instructor office hours every Tuesday from 12:30 pm to 1:30 p.m.**



EEC2146: Electronic Circuits and Measurements

Tutorials

- Every week the instructor will assign a problem set from the text book that deals with the covered sections in the lectures.
- In the tutorial, some of the assigned problems will be worked out on the board.
- At the end of some tutorials you will be asked to solve and submit one or two of the assigned problems. (At least three quizzes will be conducted during this course).
- At the beginning of the following week you will be asked to hand in another set of problems (assignment).



EEC2146: Electronic Circuits and Measurements

Marking Scheme

| | |
|----------------------------|-------------------|
| Quizzes (2 Quizzes) | 10 Degrees |
| Assignments | 5 Degrees |
| Attendance | 5 Degrees |
| Mid Term | 15 Degrees |
| Lecture Activity | 5 Degrees |
| Final | 85 Degrees |
| Total | 125 |

Final Exam Time : 3 Hours



Course Objectives

- Analyze the performance of the amplifier circuits response under different frequencies.
- Analyze the performance of practical Power amplifier circuits.
- Identify the different type of feedback and analyze the amplifier circuits under feedback effect.
- Write the equations of voltage gain and input impedance and o/p impedance of different operational amplifier circuits .
- Analyze the power supply circuits.



Course Time Table

| Day | Content |
|---------------------|---------------------------------------|
| 30/9/2015 | Review over DC and AC Analysis of BJT |
| 7/10/2015 | Review over DC and AC Analysis of FET |
| 14/10/2015 | LEC.1 On Frequency Response |
| 21/10/2015 | LEC.2 On Frequency Response |
| 28/10/2015 | LEC.1 On Power Amplifier |
| 4/11/2015 | LEC.2 On Power Amplifier |
| 11/11/2015 | LEC.1 On Feedback |
| 18/11/2015 | Mid Term Exam |
| 25/11/2015 | LEC.2 On Feedback |
| 2/12/2015 | LEC.1 Op- Amp |
| 9/12/2015 | LEC.2 Op- Amp |
| 16/12/2015 | LEC.3 Op- Amp |
| 23/12/2015 | LEC.1 Power Supply |
| Electron 30/12/2015 | LEC.2 Power Supply |



EEC2146: Electronic Circuits and Measurements

BJT Transistors

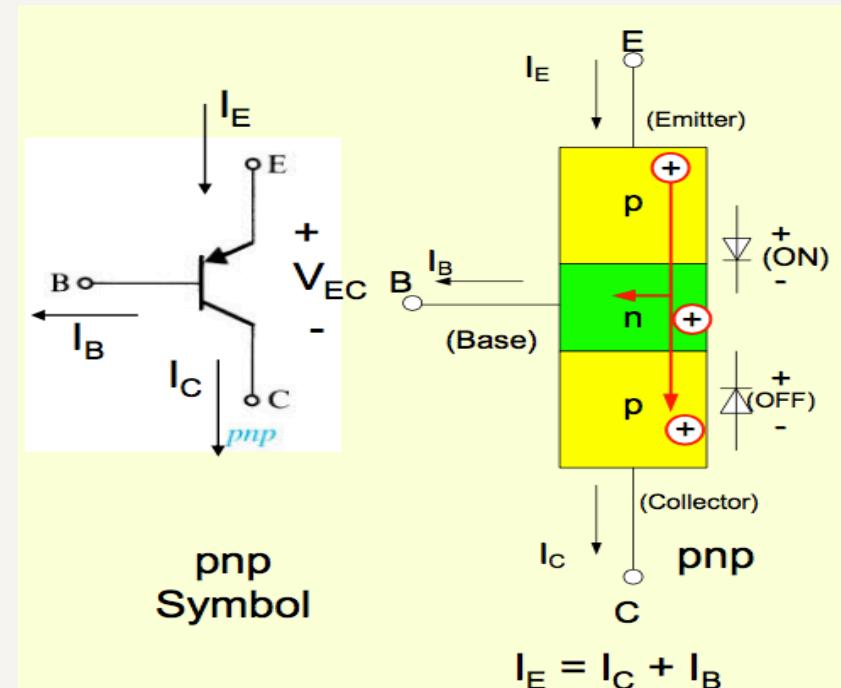
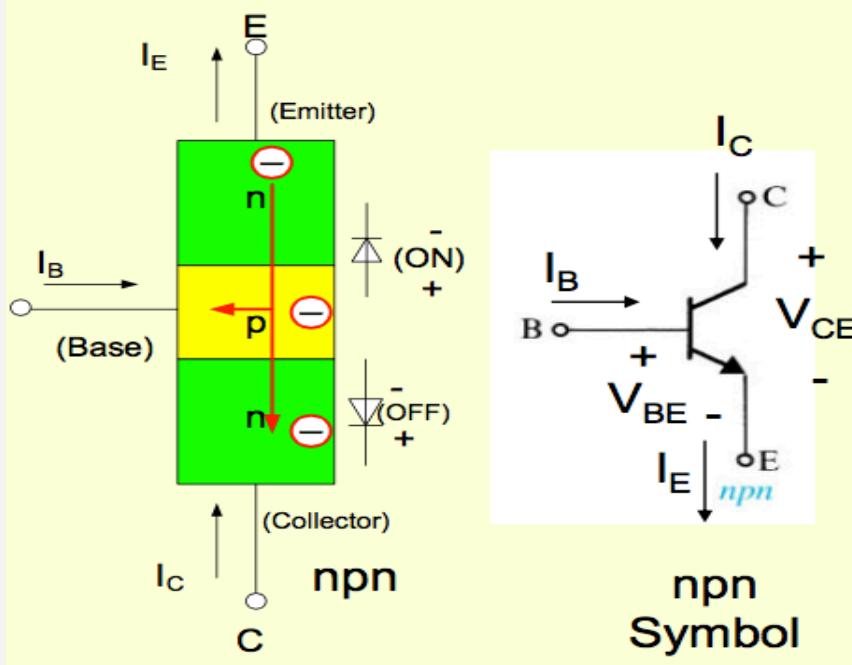
Objectives and outline:

1. Structure of BJT transistors
2. Basic operation
3. Modes of operation
4. Integrated Circuits NPN and PNP Transistors
5. I-V characteristics of A practical BJT
6. DC analysis
7. Small signal model of BJT
8. AC analysis of BJT Amplifiers



BJT Transistors

1. Structure of BJT transistors





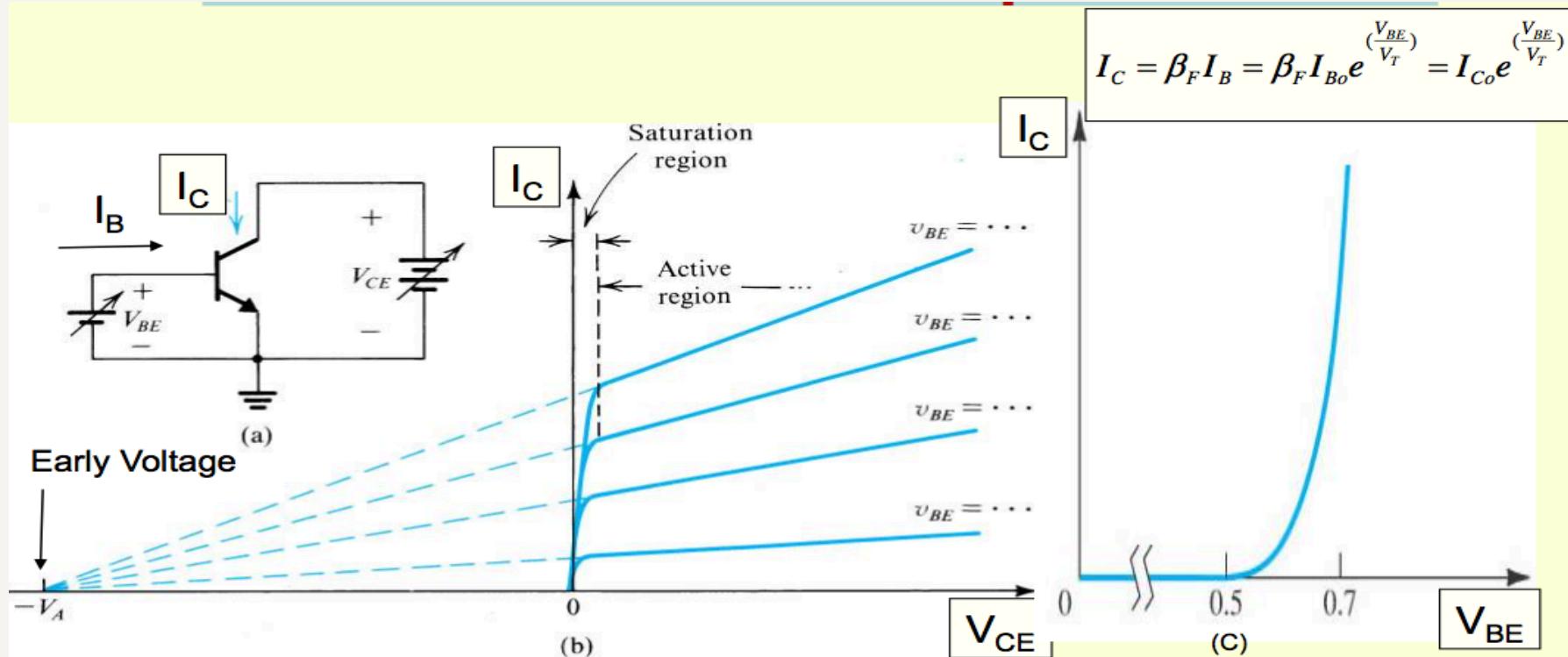
BJT Transistors

Modes of Operation

| <i>EB Junction</i> | <i>CB Junction</i> | <i>Mode</i> |
|------------------------------|------------------------------|--------------------------------------|
| ON ($V_{BE} = 0.7$ V) | Off (O.C) | Active mode (Amplification mode) |
| ON ($V_{BE,sat} = 0.7$) | ON ($V_{BC,sat} = 0.5$) | Saturation mode (switch) |
| Off (O.C) | Off (O.C) | Off mode (switch) |

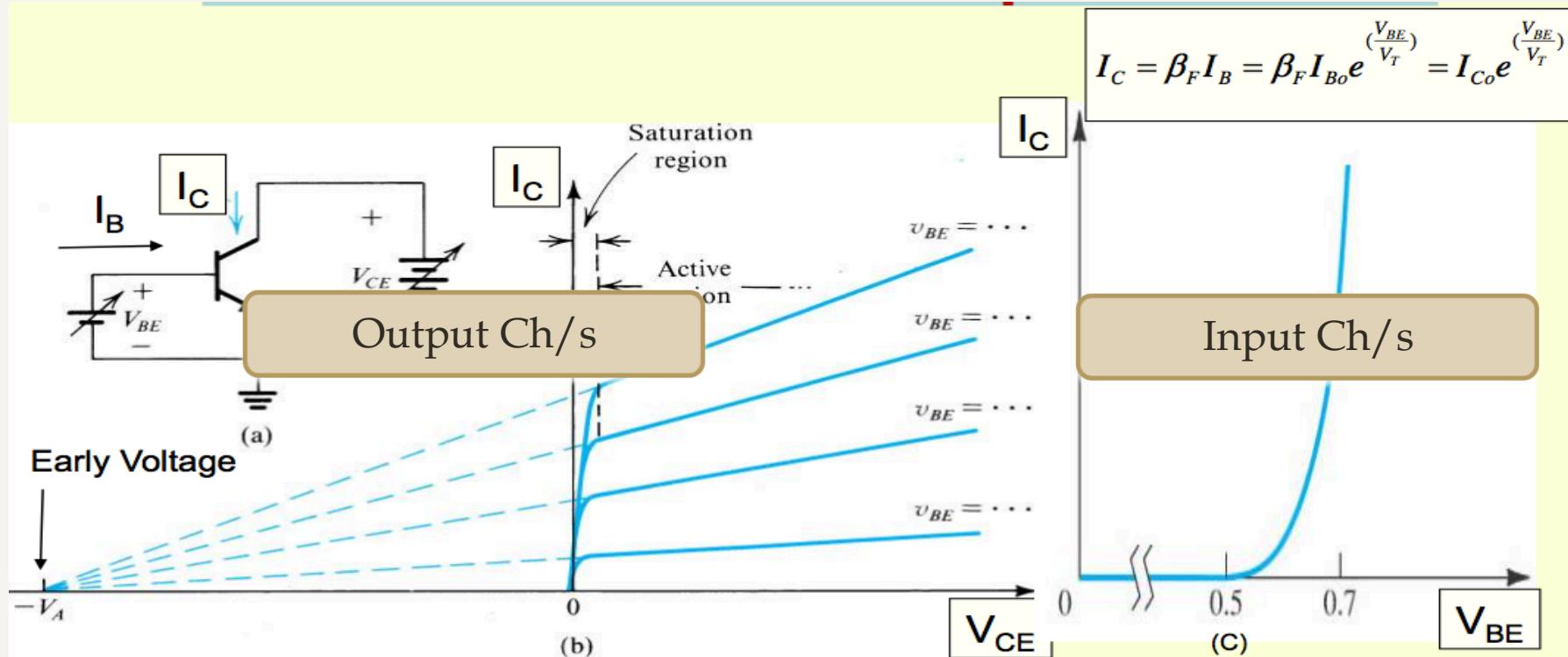
BJT Transistors

I-V characteristics of A practical BJT



BJT Transistors

I-V characteristics of A practical BJT





BJT Transistors

DC Analysis:

- Determine the type of BJT (i.e. NPN or PNP).
- Determine the terminals of BJT (E, B, C).
- Distribute the currents on the BJT (I_E , I_C , I_B).
- Distribute different voltage on the BJT (V_{BE} , V_{CE}).
- KVL around V_{BE} loop.(determine I_B).
- KVL around V_{CE} loop.

$$V_{BE} = 0.7 \text{ V}$$

$$I_E = (\beta + 1)I_B \cong I_C$$

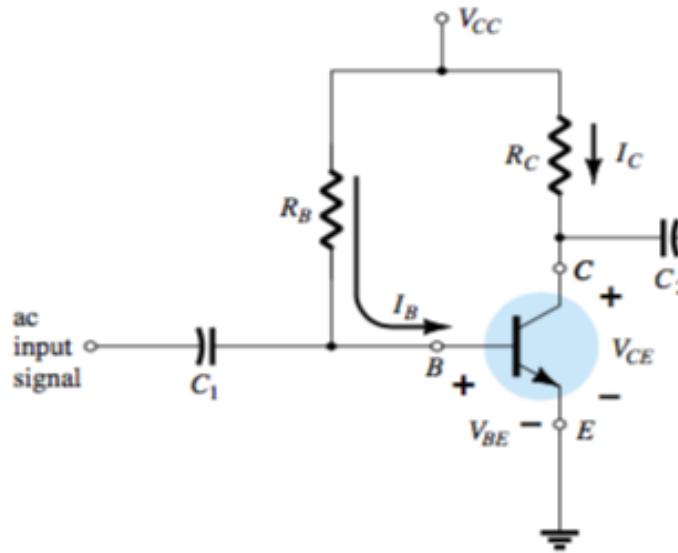
$$I_C = \beta I_B$$



BJT Transistors

DC Analysis (Fixed Bias):

$$V_{BE} = 0.7 \text{ V}$$
$$I_E = (\beta + 1)I_B \approx I_C$$
$$I_C = \beta I_B$$



DC
Analysis



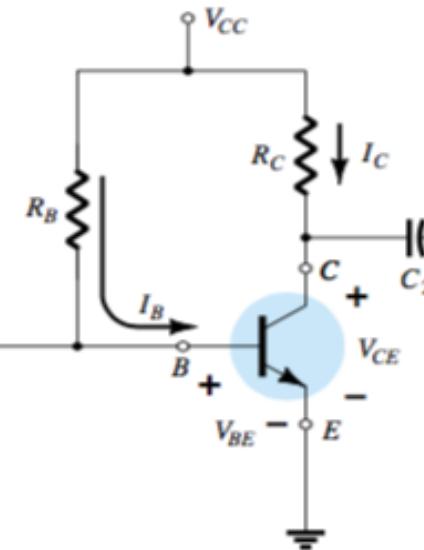
- 1- Put all capacitors O.C.
- 2- Put all coils O.C.
- 3- Put all A.C sources short circuit.



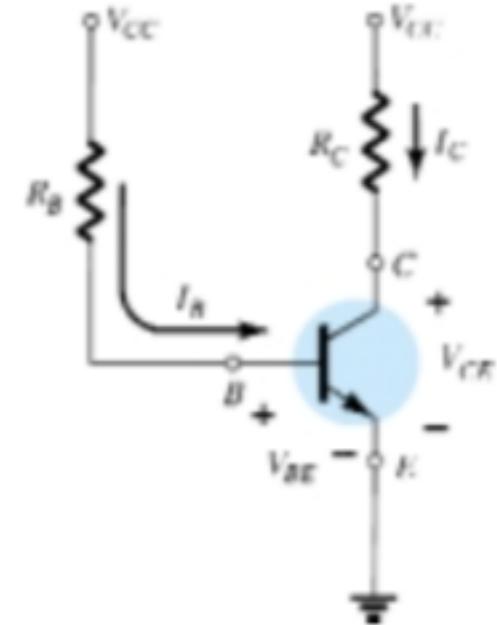
BJT Transistors

DC Analysis (Fixed Bias):

$$V_{BE} = 0.7 \text{ V}$$
$$I_E = (\beta + 1)I_B \approx I_C$$
$$I_C = \beta I_B$$



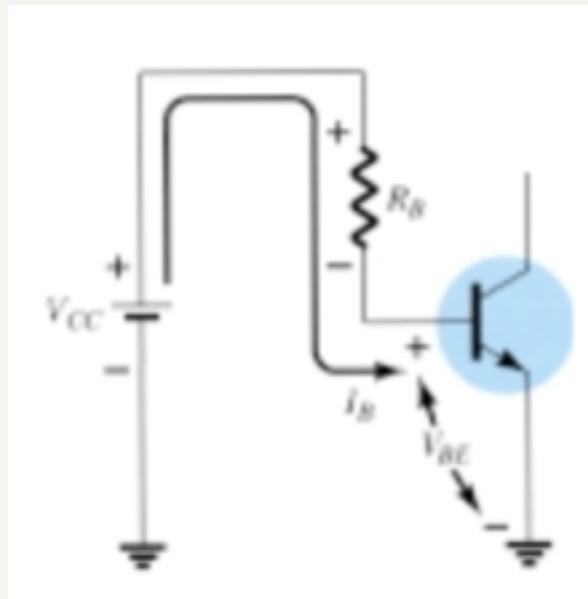
DC
Analysis





BJT Transistors

DC Analysis (Fixed Bias):



$$+V_{CC} - I_B R_B - V_{BE} = 0$$

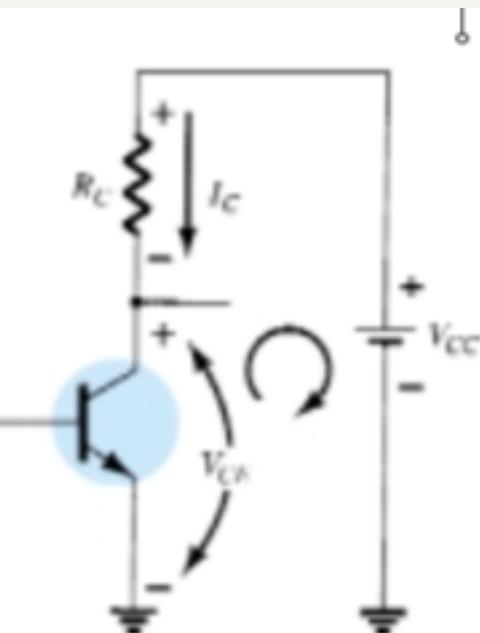
$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$

$$I_C = \beta I_B$$



BJT Transistors

DC Analysis (Fixed Bias):



$$V_{BE} = 0.7 \text{ V}$$

$$I_E = (\beta + 1)I_B \approx I_C$$

$$I_C = \beta I_B$$

$$V_{CE} + I_C R_C - V_{CC} = 0$$

$$V_{CE} = V_{CC} - I_C R_C$$

$$V_{CE} = V_C - V_E$$

$$V_{CE} = V_C$$

$$V_{BE} = V_B - V_E$$

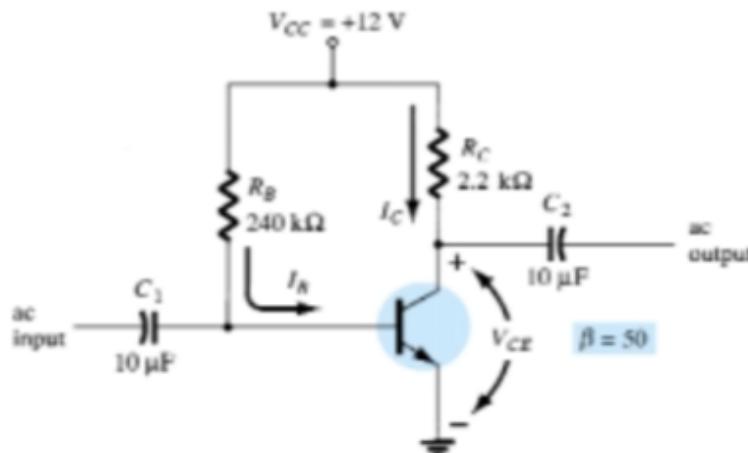


BJT Transistors

DC Analysis (Fixed Bias):

Determine the following for the fixed-bias configuration

- (a) I_{B_Q} and I_{C_Q} .
- (b) V_{CE_Q} .
- (c) V_B and V_C .
- (d) V_{BC} .



$$I_{B_Q} = \frac{V_{CC} - V_{BE}}{R_B} = \frac{12 \text{ V} - 0.7 \text{ V}}{240 \text{ k}\Omega} = 47.08 \text{ }\mu\text{A}$$

$$I_{C_Q} = \beta I_{B_Q} = (50)(47.08 \text{ }\mu\text{A}) = 2.35 \text{ mA}$$

$$\begin{aligned} V_{CE_Q} &= V_{CC} - I_C R_C \\ &= 12 \text{ V} - (2.35 \text{ mA})(2.2 \text{ k}\Omega) \\ &= 6.83 \text{ V} \end{aligned}$$

$$V_B = V_{BE} = 0.7 \text{ V}$$

$$V_C = V_{CE} = 6.83 \text{ V}$$

$$\begin{aligned} V_{BC} &= V_B - V_C = 0.7 \text{ V} - 6.83 \text{ V} \\ &= -6.13 \text{ V} \end{aligned}$$



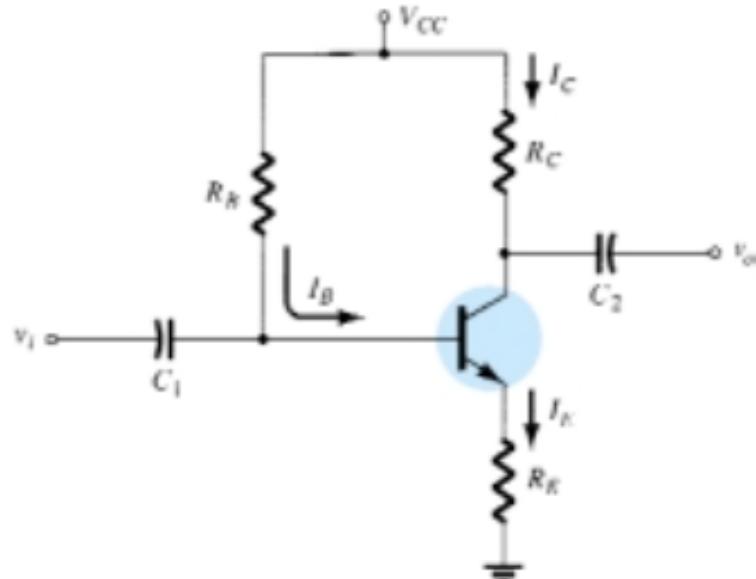
BJT Transistors

DC Analysis (Emitter Stabilized):

$$V_{BE} = 0.7 \text{ V}$$

$$I_E = (\beta + 1)I_B \approx I_C$$

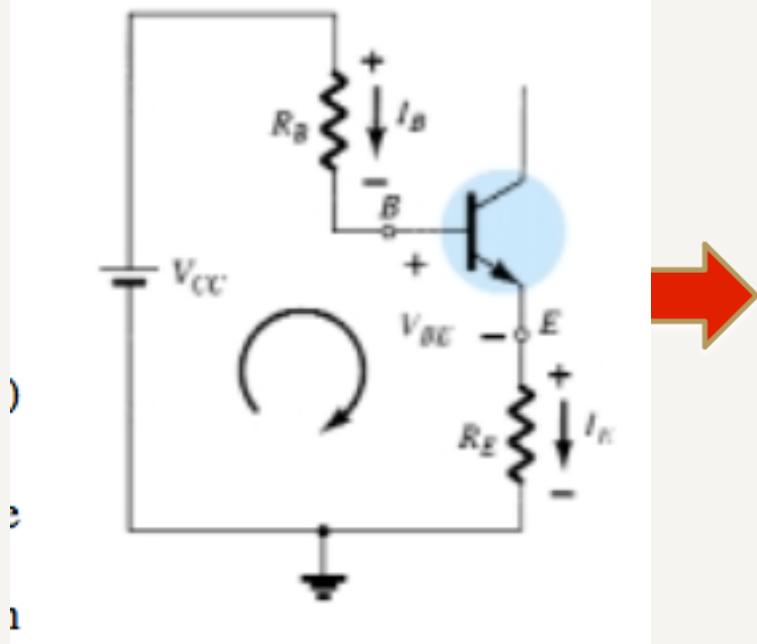
$$I_C = \beta I_B$$





BJT Transistors

DC Analysis (Emitter Stabilized):



$$+V_{CC} - I_B R_B - V_{BE} - I_E R_E = 0$$

$$I_E = (\beta + 1)I_B$$

$$V_{CC} - I_B R_B - V_{BE} - (\beta + 1)I_B R_E = 0$$

$$-I_B(R_B + (\beta + 1)R_E) + V_{CC} - V_{BE} = 0$$

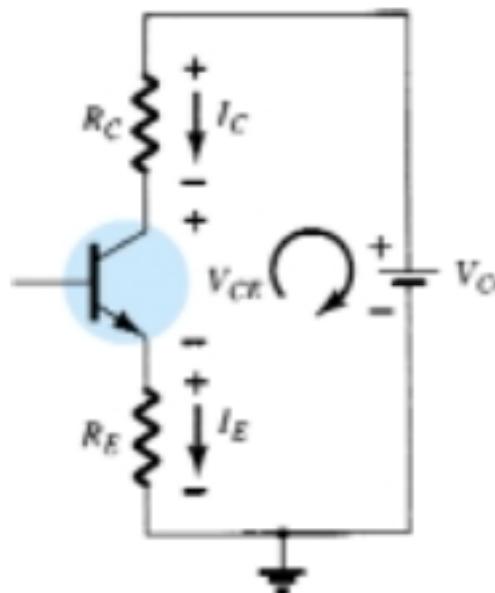
$$I_B(R_B + (\beta + 1)R_E) - V_{CC} + V_{BE} = 0$$
$$I_B(R_B + (\beta + 1)R_E) = V_{CC} - V_{BE}$$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta + 1)R_E}$$



BJT Transistors

DC Analysis (Emitter Stabilized):



$$+I_E R_E + V_{CE} + I_C R_C - V_{CC} = 0$$

$$V_{CE} - V_{CC} + I_C (R_C + R_E) = 0$$

$$V_{CE} = V_{CC} - I_C (R_C + R_E)$$

$$V_E = I_E R_E$$

$$V_{CE} = V_C - V_E$$

$$V_C = V_{CE} + V_E$$

$$V_C = V_{CC} - I_C R_C$$

$$V_B = V_{CC} - I_B R_B$$

$$V_B = V_{BE} + V_E$$



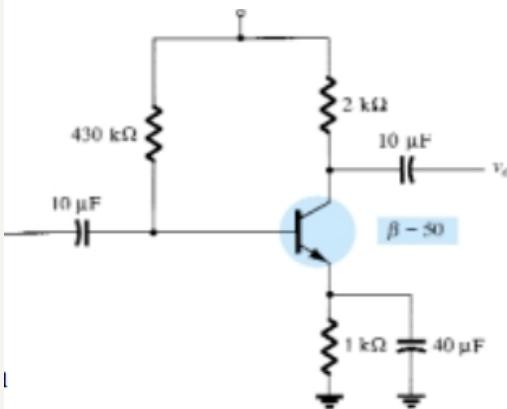
BJT Transistors

DC Analysis (Emitter Stabilized):

- (a) I_B .
- (b) I_C .
- (c) V_{CE} .
- (d) V_C .
- (e) V_E .
- (f) V_B .
- (g) V_{BC} .



$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (\beta + 1)R_E} = \frac{20 \text{ V} - 0.7 \text{ V}}{430 \text{ k}\Omega + (51)(1 \text{ k}\Omega)}$$
$$= \frac{19.3 \text{ V}}{481 \text{ k}\Omega} = 40.1 \text{ }\mu\text{A}$$



$$I_C = \beta I_B$$
$$= (50)(40.1 \text{ }\mu\text{A})$$
$$\cong 2.01 \text{ mA}$$

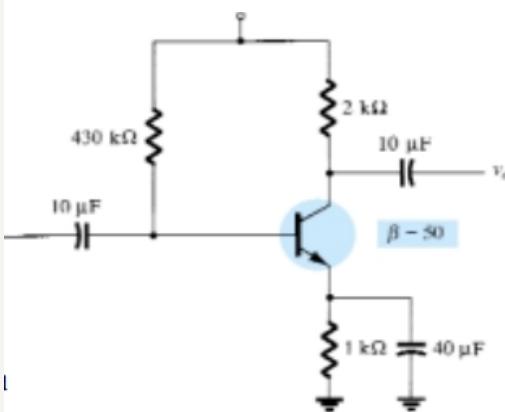
$$V_{CE} = V_{CC} - I_C(R_C + R_E)$$
$$= 20 \text{ V} - (2.01 \text{ mA})(2 \text{ k}\Omega + 1 \text{ k}\Omega) = 20 \text{ V} - 6.03 \text{ V}$$
$$= 13.97 \text{ V}$$



BJT Transistors

DC Analysis (Emitter Stabilized):

- (a) I_B .
- (b) I_C .
- (c) V_{CE} .
- (d) V_C .
- (e) V_E .
- (f) V_B .
- (g) V_{BC} .



$$\begin{aligned}V_C &= V_{CC} - I_C R_C \\&= 20 \text{ V} - (2.01 \text{ mA})(2 \text{ k}\Omega) = 20 \text{ V} - 4.02 \text{ V} \\&= \mathbf{15.98 \text{ V}}\end{aligned}$$

$$\begin{aligned}V_E &= V_C - V_{CE} \\&= 15.98 \text{ V} - 13.97 \text{ V} \\&= \mathbf{2.01 \text{ V}}\end{aligned}$$

$$\begin{aligned}V_B &= V_{BE} + V_E \\&= 0.7 \text{ V} + 2.01 \text{ V} \\&= \mathbf{2.71 \text{ V}}\end{aligned}$$

$$\begin{aligned}V_{BC} &= V_B - V_C \\&= 2.71 \text{ V} - 15.98 \text{ V} \\&= \mathbf{-13.27 \text{ V}} \quad (\text{reverse-biased as required})\end{aligned}$$



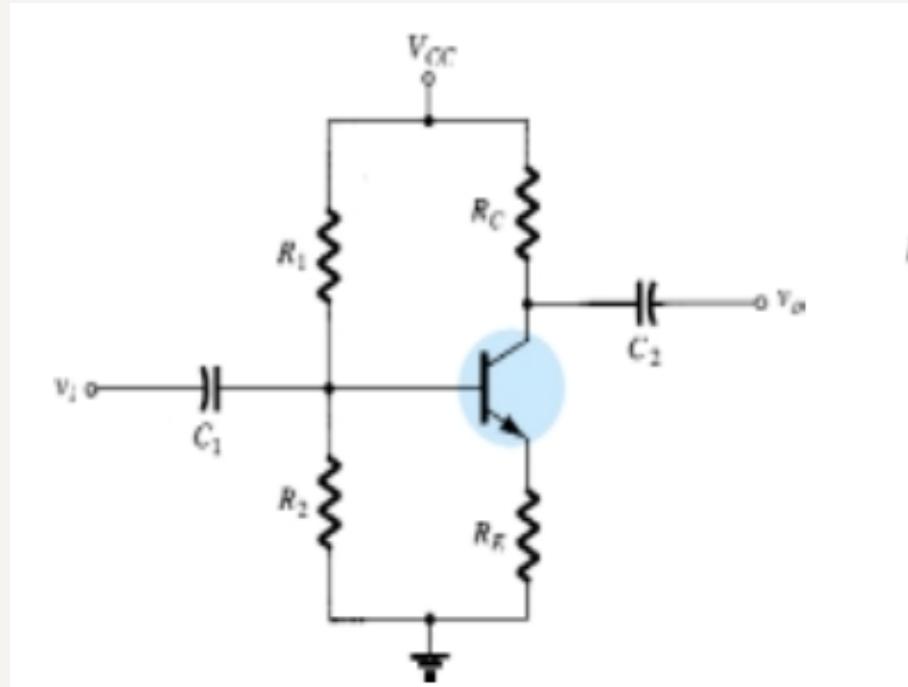
BJT Transistors

DC Analysis (Voltage Divider):

$$V_{BE} = 0.7 \text{ V}$$

$$I_E = (\beta + 1)I_B \approx I_C$$

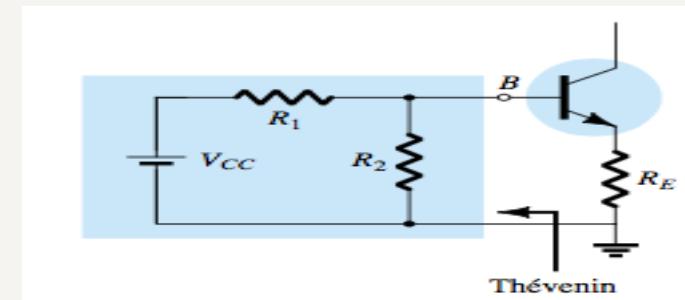
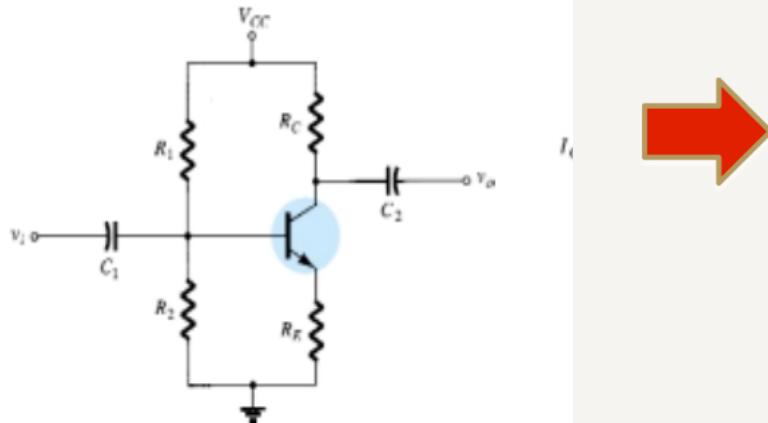
$$I_C = \beta I_B$$



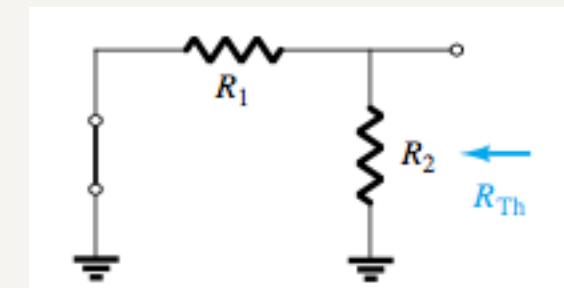


BJT Transistors

DC Analysis (Voltage Divider):



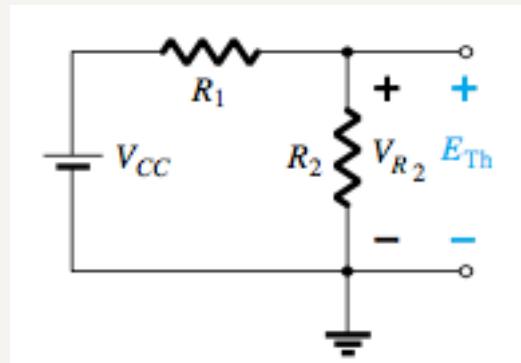
$$R_{Th} = R_1 \parallel R_2$$



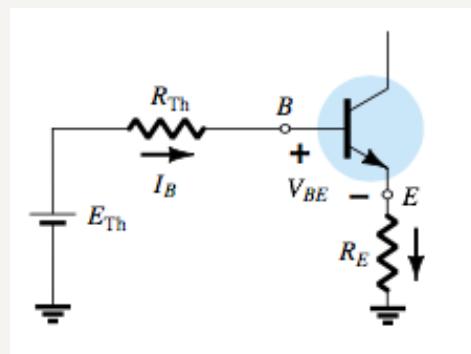


BJT Transistors

DC Analysis (Voltage Divider):



$$E_{Th} = V_{R_2} = \frac{R_2 V_{CC}}{R_1 + R_2}$$



$$I_B = \frac{E_{Th} - V_{BE}}{R_{Th} + (\beta + 1)R_E}$$

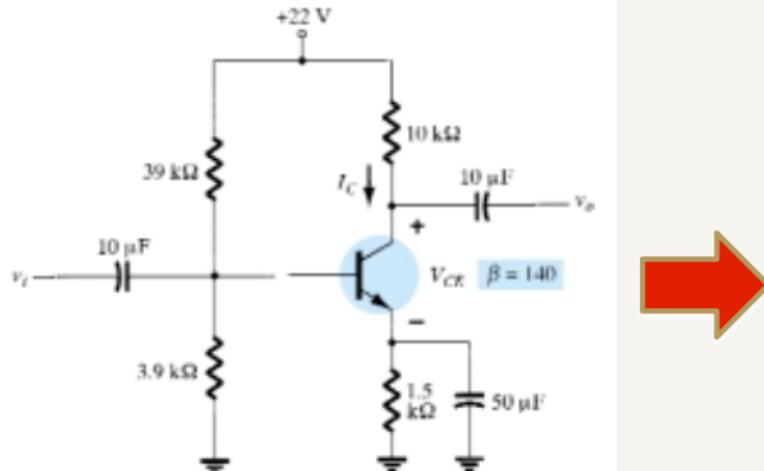
$$V_{CE} = V_{CC} - I_C(R_C + R_E)$$



BJT Transistors

DC Analysis (Voltage Divider):

Determine the dc bias voltage V_{CE} and the current I_C for the voltage-divider



$$R_{Th} = R_1 \parallel R_2$$
$$= \frac{(39 \text{ k}\Omega)(3.9 \text{ k}\Omega)}{39 \text{ k}\Omega + 3.9 \text{ k}\Omega} = 3.55 \text{ k}\Omega$$

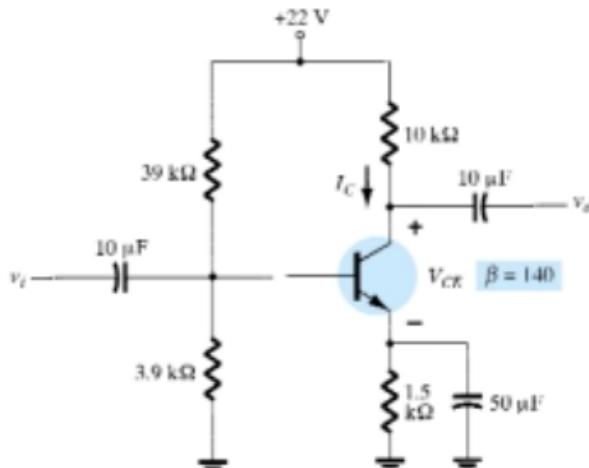
$$E_{Th} = \frac{R_2 V_{CC}}{R_1 + R_2}$$
$$= \frac{(3.9 \text{ k}\Omega)(22 \text{ V})}{39 \text{ k}\Omega + 3.9 \text{ k}\Omega} = 2 \text{ V}$$



BJT Transistors

DC Analysis (Voltage Divider):

Determine the dc bias voltage V_{CE} and the current I_C for the voltage-divider



$$\begin{aligned} I_B &= \frac{E_{Th} - V_{BE}}{R_{Th} + (\beta + 1)R_E} \\ &= \frac{2\text{ V} - 0.7\text{ V}}{3.55\text{ k}\Omega + (141)(1.5\text{ k}\Omega)} = \frac{1.3\text{ V}}{3.55\text{ k}\Omega + 211.5\text{ k}\Omega} \\ &= 6.05\text{ }\mu\text{A} \\ I_C &= \beta I_B \\ &= (140)(6.05\text{ }\mu\text{A}) \\ &= \mathbf{0.85\text{ mA}} \end{aligned}$$

$$\begin{aligned} V_{CE} &= V_{CC} - I_C(R_C + R_E) \\ &= 22\text{ V} - (0.85\text{ mA})(10\text{ k}\Omega + 1.5\text{ k}\Omega) \\ &= 22\text{ V} - 9.78\text{ V} \\ &= \mathbf{12.22\text{ V}} \end{aligned}$$



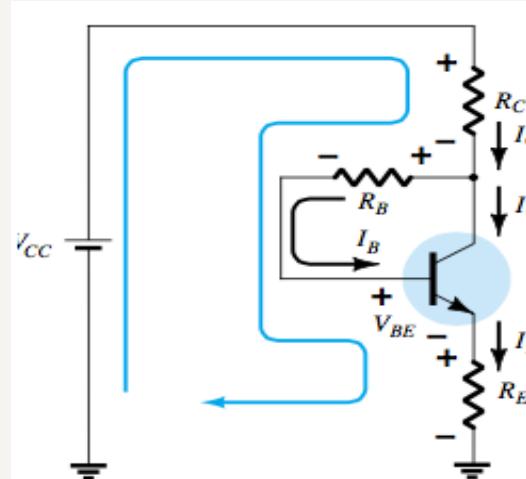
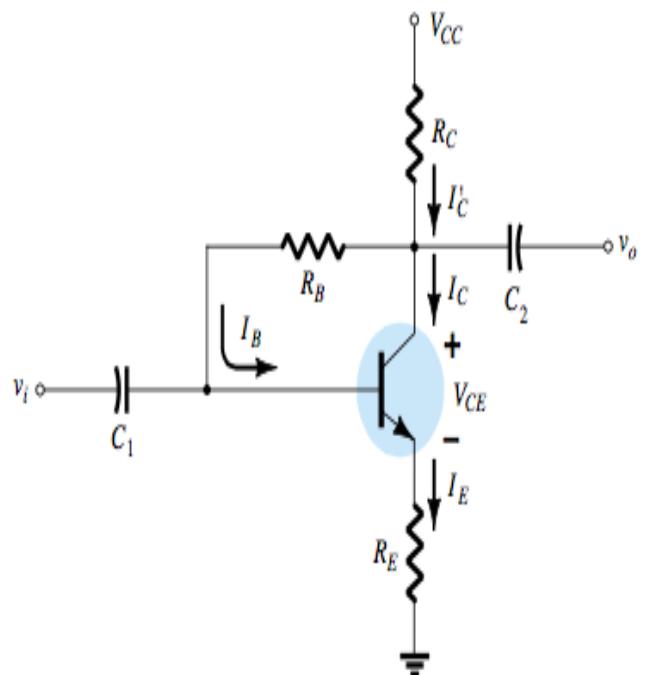
BJT Transistors

DC Analysis (Voltage Feedback):

$$V_{BE} = 0.7 \text{ V}$$

$$I_E = (\beta + 1)I_B \approx I_C$$

$$I_C = \beta I_B$$



$$V_{CC} - I'_C R_C - I_B R_B - V_{BE} - I_E R_E = 0$$

$$V_{CC} - \beta I_B R_C - I_B R_B - V_{BE} - \beta I_B R_E = 0$$



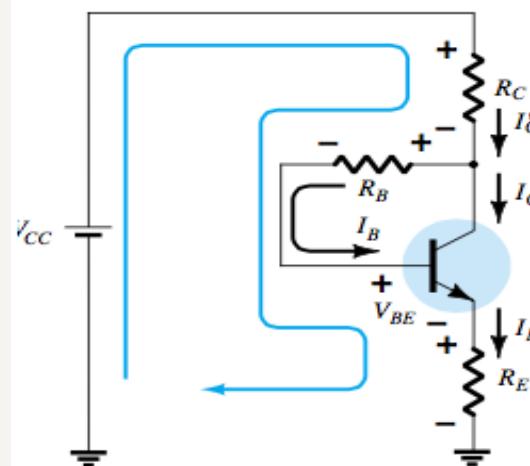
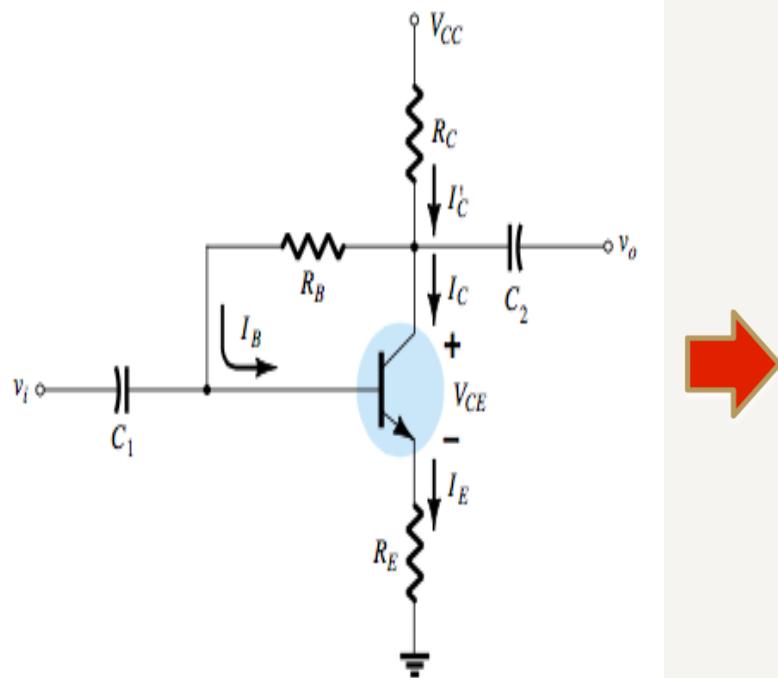
BJT Transistors

DC Analysis (Voltage Feedback):

$$V_{BE} = 0.7 \text{ V}$$

$$I_E = (\beta + 1)I_B \approx I_C$$

$$I_C = \beta I_B$$



$$I_B = \frac{V_{CC} - V_{BE}}{R_B + \beta(R_C + R_E)}$$



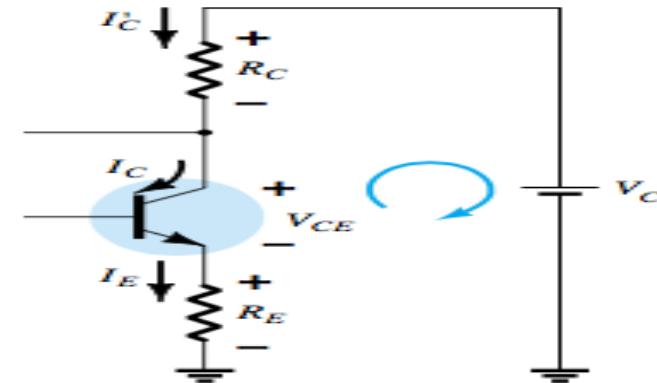
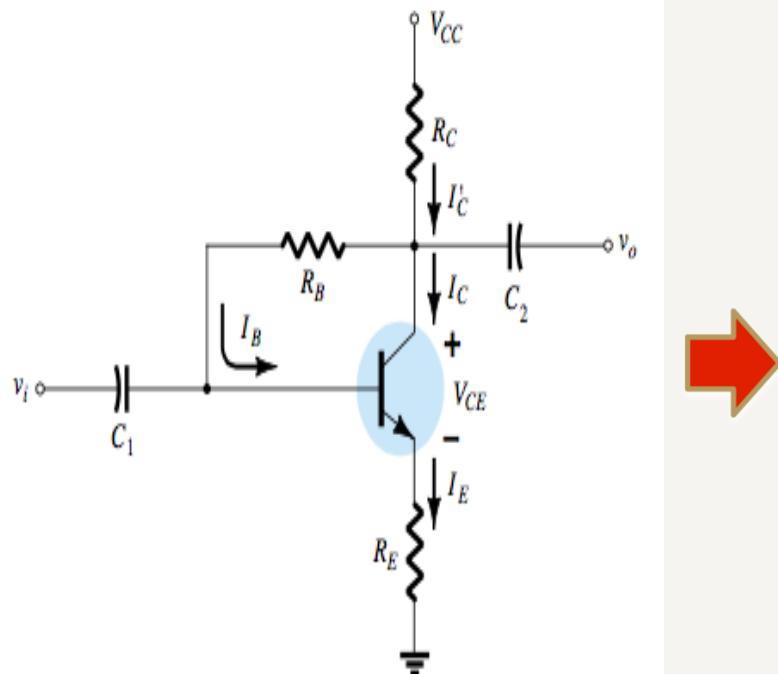
BJT Transistors

DC Analysis (Voltage Feedback):

$$V_{BE} = 0.7 \text{ V}$$

$$I_E = (\beta + 1)I_B \approx I_C$$

$$I_C = \beta I_B$$



$$I_E R_E + V_{CE} + I'_C R_C - V_{CC} = 0$$

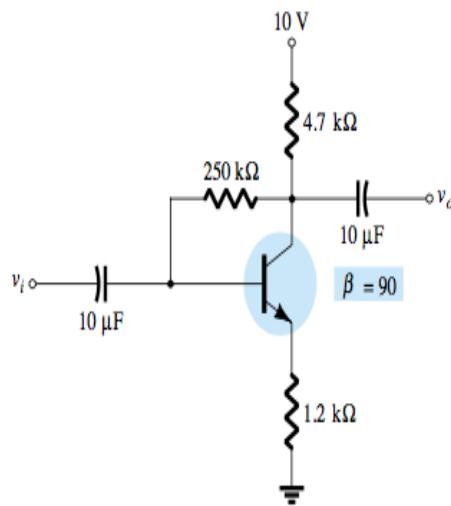
$$I_C (R_C + R_E) + V_{CE} - V_{CC} = 0$$

$$V_{CE} = V_{CC} - I_C (R_C + R_E)$$



BJT Transistors

DC Analysis (Voltage Feedback):



$$\begin{aligned}I_B &= \frac{V_{CC} - V_{BE}}{R_B + \beta(R_C + R_E)} \\&= \frac{10 \text{ V} - 0.7 \text{ V}}{250 \text{ k}\Omega + (90)(4.7 \text{ k}\Omega + 1.2 \text{ k}\Omega)} \\&= \frac{9.3 \text{ V}}{250 \text{ k}\Omega + 531 \text{ k}\Omega} = \frac{9.3 \text{ V}}{781 \text{ k}\Omega} \\&= 11.91 \text{ }\mu\text{A}\end{aligned}$$

$$\begin{aligned}V_{CEo} &= V_{CC} - I_C(R_C + R_E) \\&= 10 \text{ V} - (1.07 \text{ mA})(4.7 \text{ k}\Omega + 1.2 \text{ k}\Omega) \\&= 10 \text{ V} - 6.31 \text{ V} \\&= 3.69 \text{ V}\end{aligned}$$

$$\begin{aligned}I_{CQ} &= \beta I_B = (90)(11.91 \text{ }\mu\text{A}) \\&= 1.07 \text{ mA}\end{aligned}$$

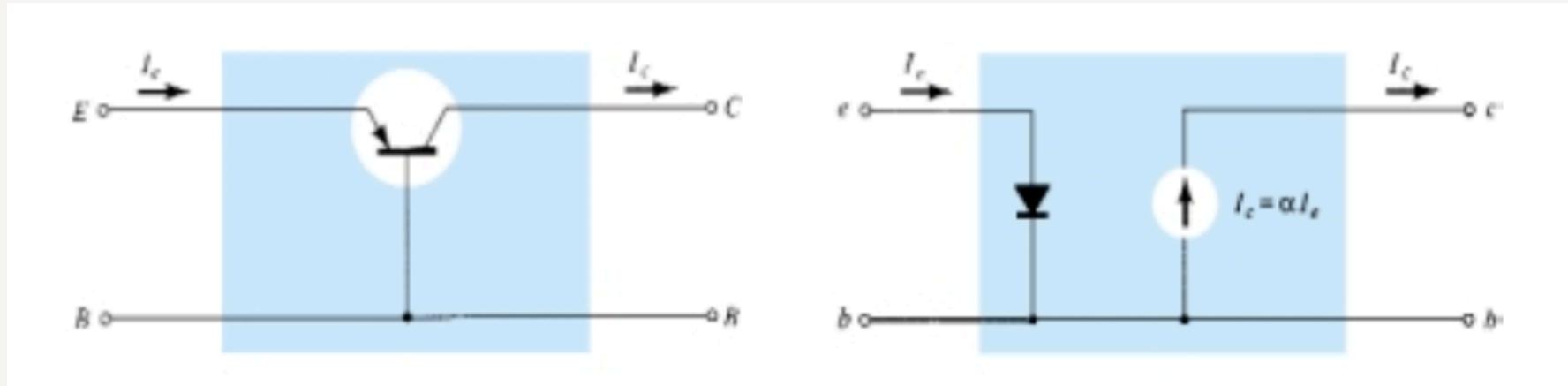
Break



BJT Transistors

AC Analysis : THE r_e TRANSISTOR MODEL

Common Base Amplifier



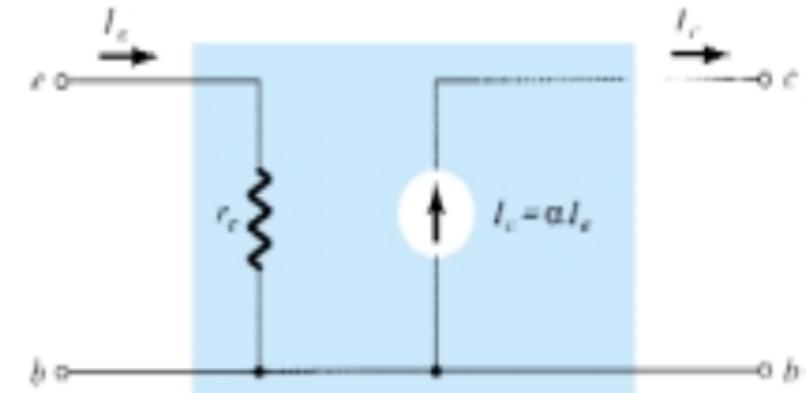
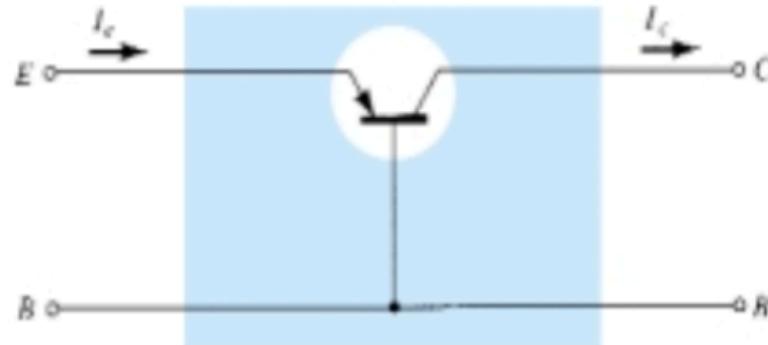


BJT Transistors

AC Analysis : THE r_e TRANSISTOR MODEL

Common Base Amplifier

$$r_e = \frac{26 \text{ mV}}{I_E}$$



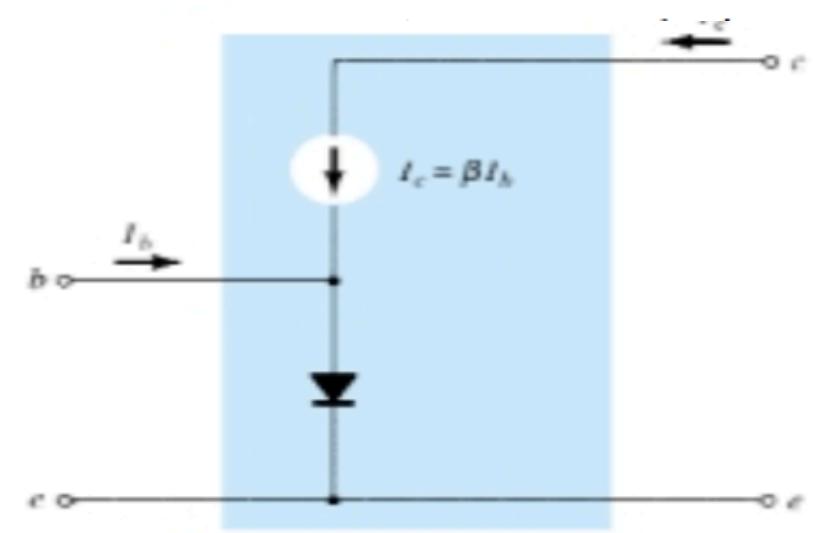
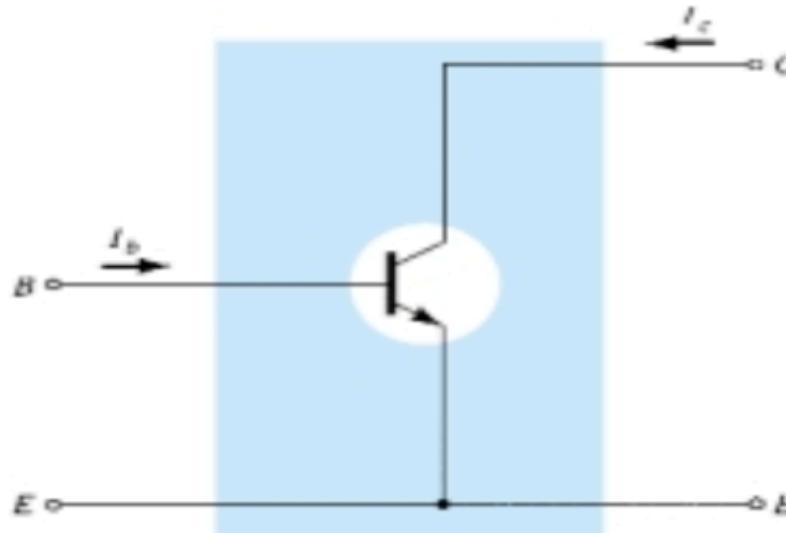


BJT Transistors

AC Analysis : THE r_e TRANSISTOR MODEL

Common Emitter Amplifier

$$r_e = \frac{26 \text{ mV}}{I_E}$$



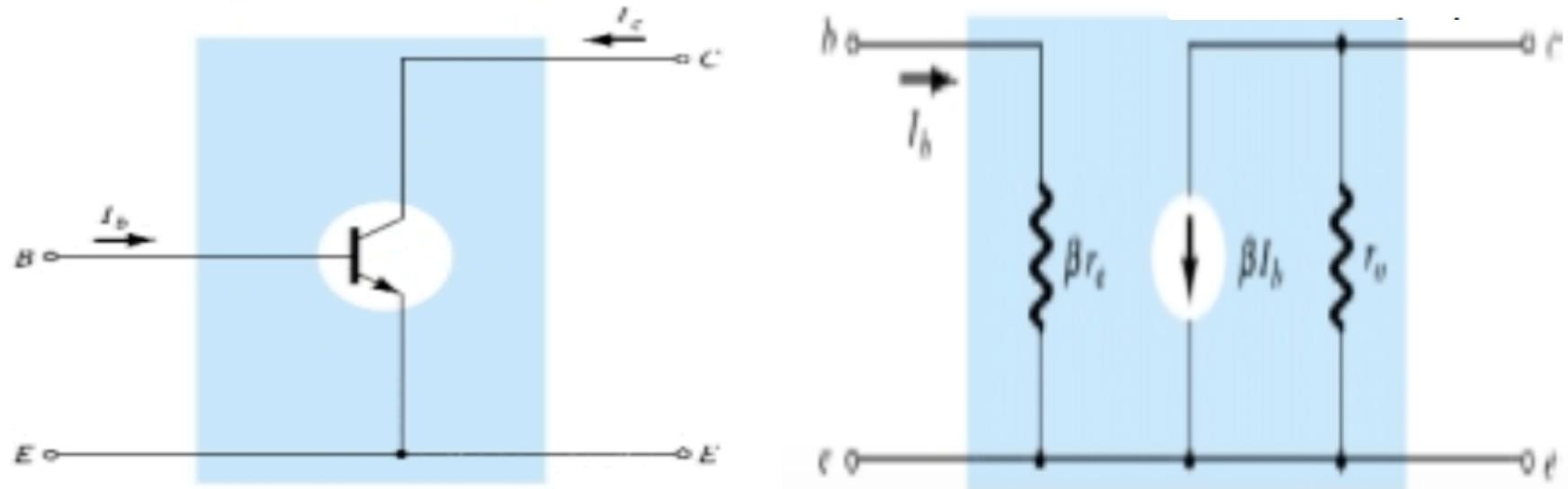


BJT Transistors

AC Analysis : THE r_e TRANSISTOR MODEL

Common Emitter Amplifier

$$r_e = \frac{26 \text{ mV}}{I_E}$$





BJT Transistors

Steps of AC Analysis :

1- Perform DC Analysis to find I_E and r_e .

$$r_e = \frac{26 \text{ mV}}{I_E}$$

2- Put all capacitors short circuit.

3- Put all DC sources short circuit.

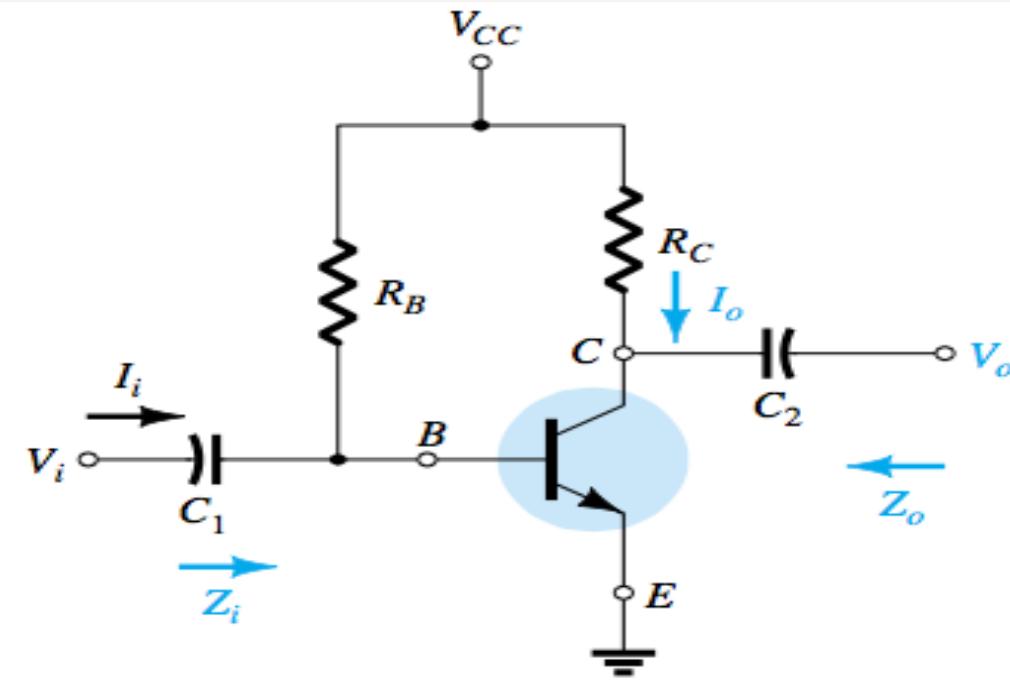
4- Draw the AC model.

5- Find Z_i , Z_o , A_v , A_i .



BJT Transistors

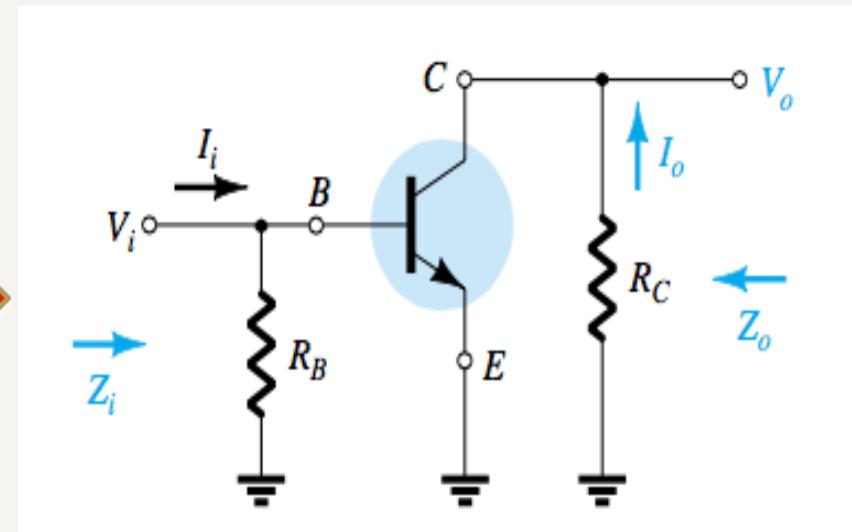
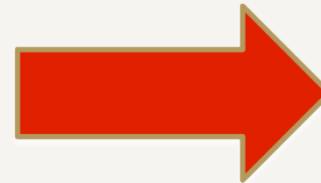
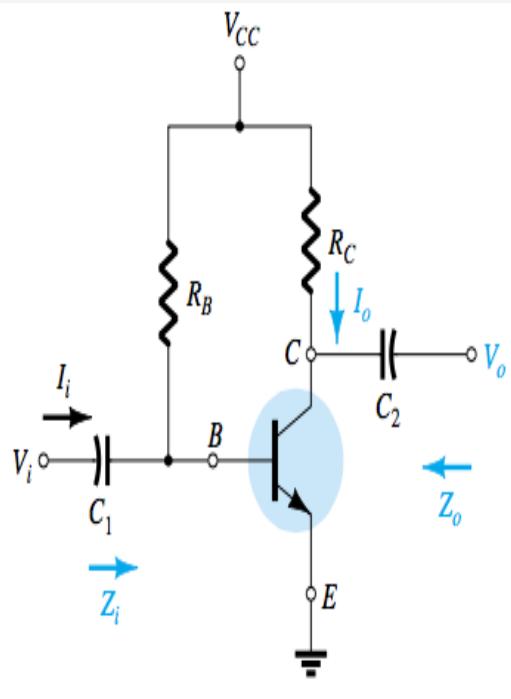
AC Analysis: **COMMON-EMITTER FIXED-BIAS CONFIGURATION.**





BJT Transistors

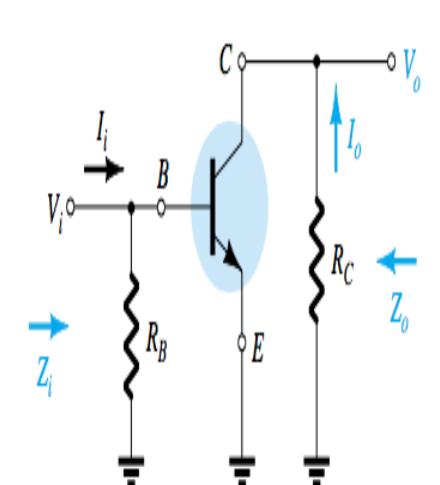
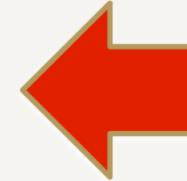
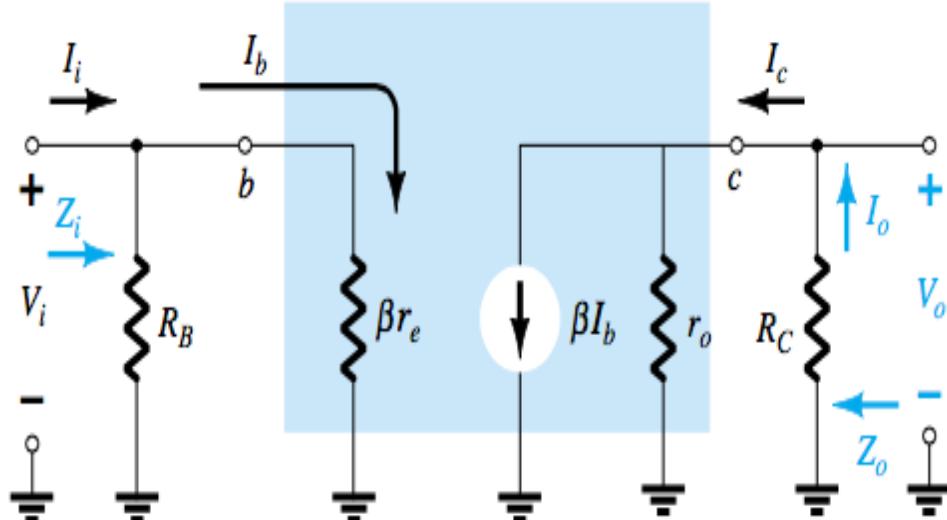
AC Analysis: **COMMON-EMITTER FIXED-BIAS CONFIGURATION.**





BJT Transistors

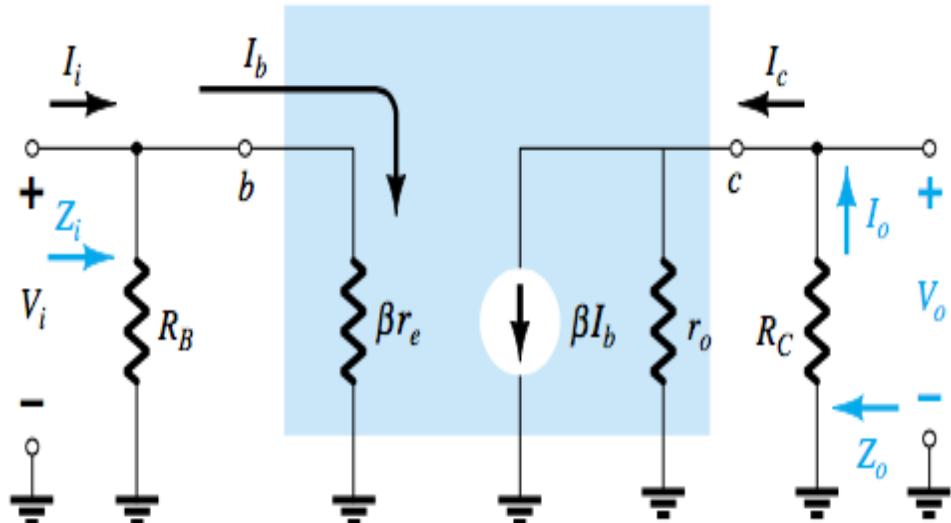
AC Analysis: **COMMON-EMITTER FIXED-BIAS CONFIGURATION.**





BJT Transistors

AC Analysis: **COMMON-EMITTER FIXED-BIAS CONFIGURATION.**

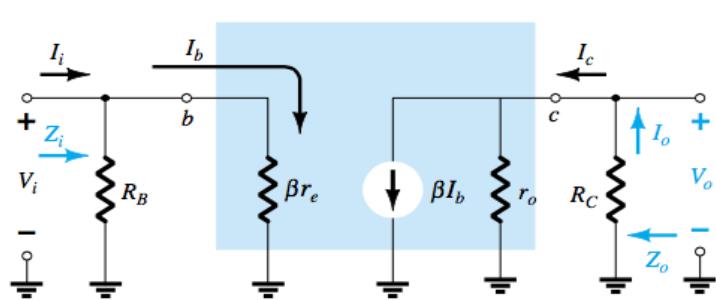


$$Z_i = R_B \parallel \beta r_e$$



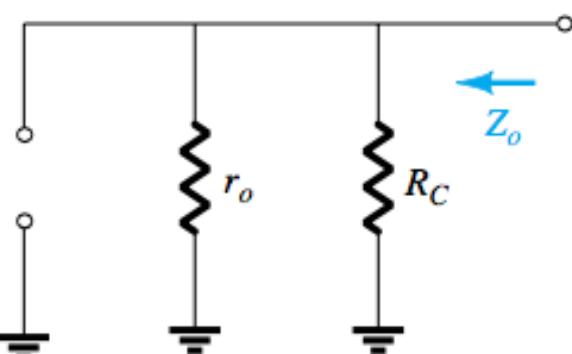
BJT Transistors

AC Analysis: **COMMON-EMITTER FIXED-BIAS CONFIGURATION.**



To find Z_o

$\dot{V}_i = 0, I_i = I_b = 0,$

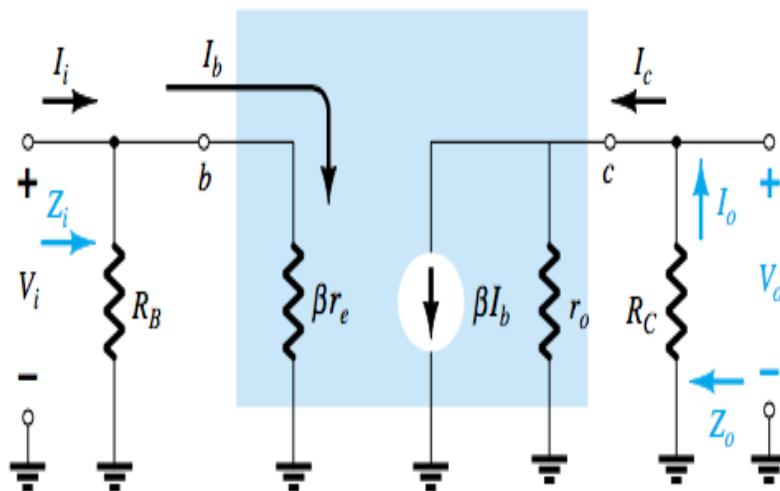


$$Z_o = R_C \parallel r_o$$



BJT Transistors

AC Analysis: **COMMON-EMITTER FIXED-BIAS CONFIGURATION.**



$$V_o = -\beta I_b (R_C \| r_o)$$

$$I_b = \frac{V_i}{\beta r_c}$$

$$V_o = -\beta \left(\frac{V_i}{\beta r_e} \right) (R_C \| r_o)$$

$$A_v = \frac{V_o}{V_i} = -\frac{(R_C \| r_o)}{r_e}$$

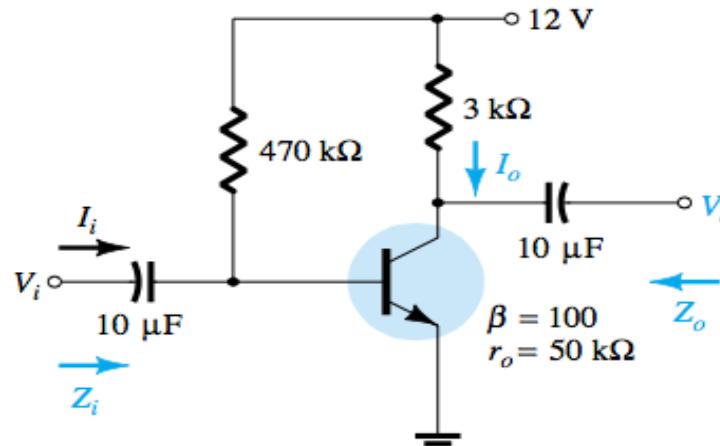
$$A_i = -A_v \frac{Z_i}{R_C}$$



BJT Transistors

AC Analysis: COMMON-EMITTER FIXED-BIAS CONFIGURATION.

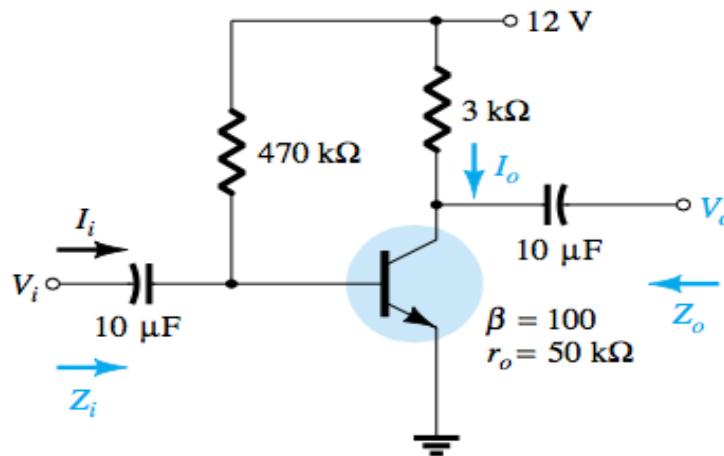
- Determine r_e .
- Find Z_i (with $r_o = \infty \Omega$).
- Calculate Z_o (with $r_o = \infty \Omega$).
- Determine A_v (with $r_o = \infty \Omega$).
- Find A_i (with $r_o = \infty \Omega$).
- Repeat parts (c) through (e) including $r_o = 50 \text{ k}\Omega$ in all calculations and compare results.





BJT Transistors

AC Analysis: **COMMON-EMITTER FIXED-BIAS CONFIGURATION.**



) DC analysis:

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{12 \text{ V} - 0.7 \text{ V}}{470 \text{ k}\Omega} = 24.04 \text{ } \mu\text{A}$$

$$I_E = (\beta + 1)I_B = (101)(24.04 \text{ } \mu\text{A}) = 2.428 \text{ mA}$$

$$r_e = \frac{26 \text{ mV}}{I_E} = \frac{26 \text{ mV}}{2.428 \text{ mA}} = 10.71 \text{ } \Omega$$

) $\beta r_e = (100)(10.71 \text{ } \Omega) = 1.071 \text{ k}\Omega$

$$Z_i = R_B \parallel \beta r_e = 470 \text{ k}\Omega \parallel 1.071 \text{ k}\Omega = 1.069 \text{ k}\Omega$$

) $Z_o = R_C = 3 \text{ k}\Omega$

) $A_v = -\frac{R_C}{r_e} = -\frac{3 \text{ k}\Omega}{10.71 \text{ } \Omega} = -280.11$

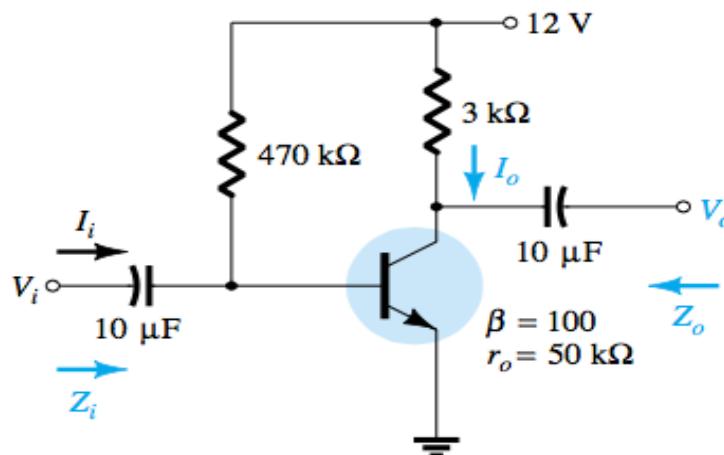
) Since $R_B \geq 10\beta r_e$ ($470 \text{ k}\Omega > 10.71 \text{ k}\Omega$)

$$A_i \cong \beta = 100$$



BJT Transistors

AC Analysis: **COMMON-EMITTER FIXED-BIAS CONFIGURATION.**



$$Z_o = r_o \| R_C = 50 \text{ k}\Omega \| 3 \text{ k}\Omega = 2.83 \text{ k}\Omega \text{ vs. } 3 \text{ k}\Omega$$

$$A_v = -\frac{r_o \| R_C}{r_e} = \frac{2.83 \text{ k}\Omega}{10.71 \Omega} = -264.24 \text{ vs. } -280.11$$

$$A_i = \frac{\beta R_B r_o}{(r_o + R_C)(R_B + \beta r_e)} = \frac{(100)(470 \text{ k}\Omega)(50 \text{ k}\Omega)}{(50 \text{ k}\Omega + 3 \text{ k}\Omega)(470 \text{ k}\Omega + 1.071 \text{ k}\Omega)} = 94.13 \text{ vs. } 100$$

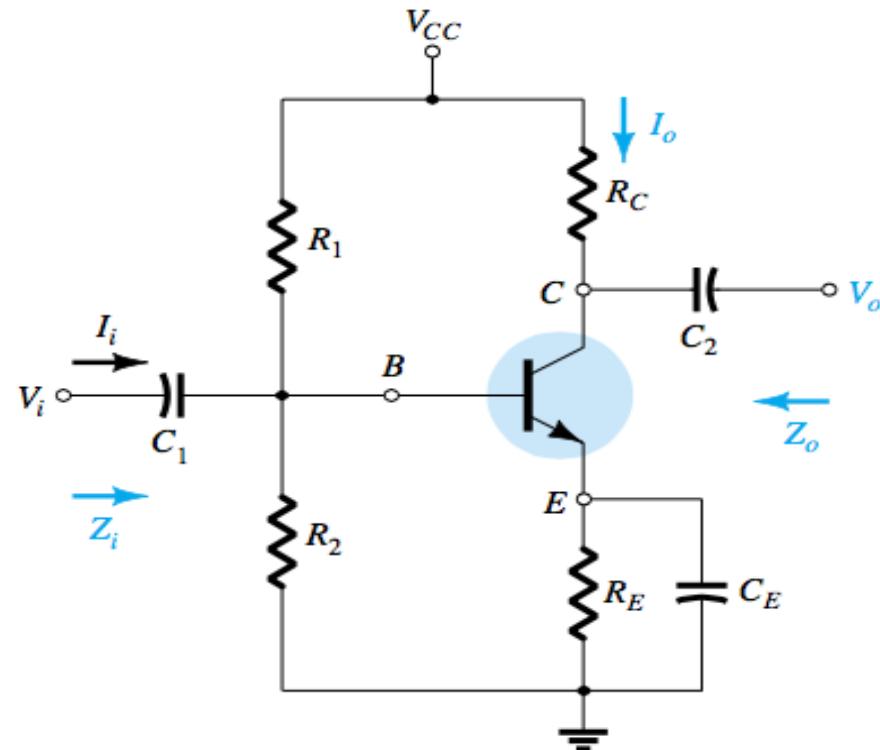
As a check:

$$A_i = -A_v \frac{Z_i}{R_C} = \frac{-(-264.24)(1.069 \text{ k}\Omega)}{3 \text{ k}\Omega} = 94.16$$



BJT Transistors

AC Analysis: **COMMON-EMITTER** Voltage Divider CONFIGURATION.



Dr.hoss

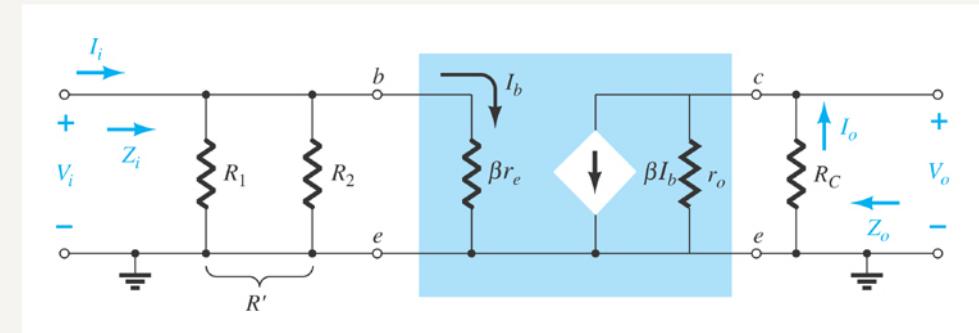
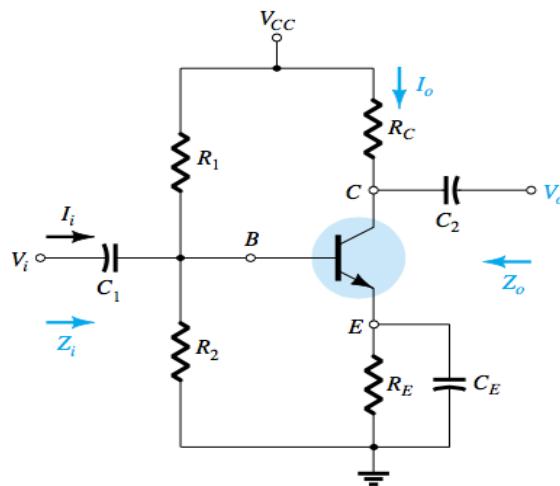
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EEC 2146



BJT Transistors

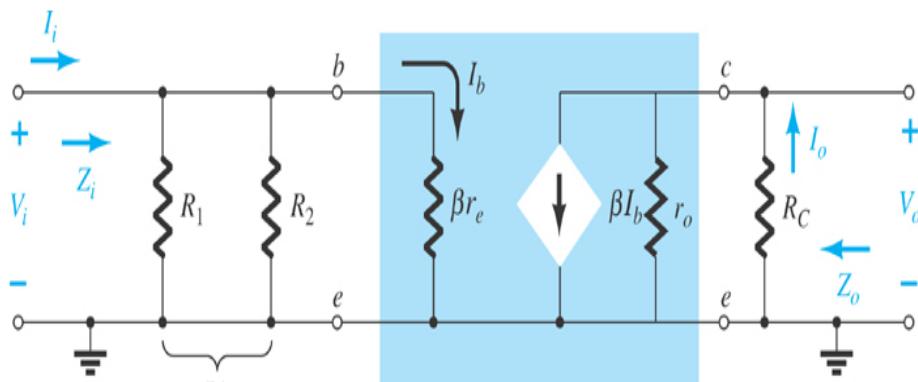
AC Analysis: **COMMON-EMITTER** Voltage Divider CONFIGURATION.





BJT Transistors

AC Analysis: **COMMON-EMITTER** Voltage Divider CONFIGURATION.



$$A_i = \frac{I_o}{I_i} = \frac{\beta R' r_o}{(r_o + R_C)(R' + \beta r_e)}$$

$$A_i = \frac{I_o}{I_i} \cong \frac{\beta R'}{R' + \beta r_e} \Big|_{r_o \geq 10R_C}$$

$$A_i = \frac{I_o}{I_i} \cong \beta \Big|_{r_o \geq 10R_C, R' \geq 10\beta r_e}$$

$$R' = R_1 \parallel R_2$$

$$Z_i = R' \parallel \beta r_e$$

$$Z_o = R_C \parallel r_o$$

$$Z_o \cong R_C \Big|_{r_o \geq 10R_C}$$

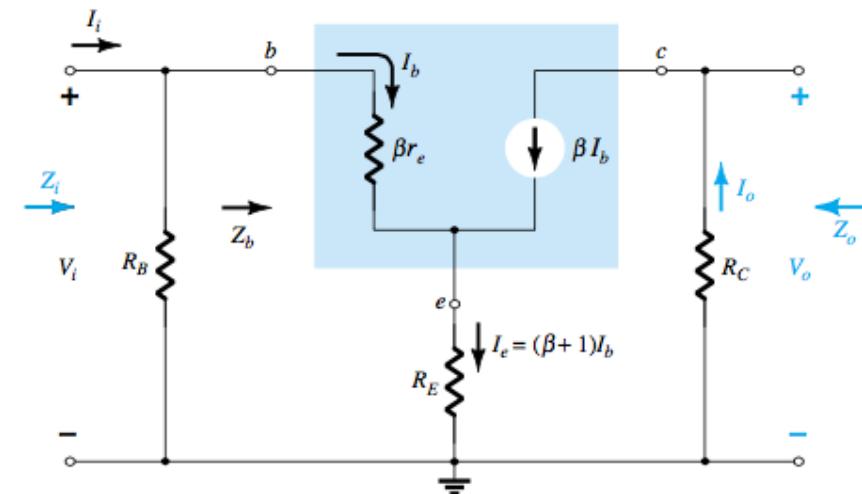
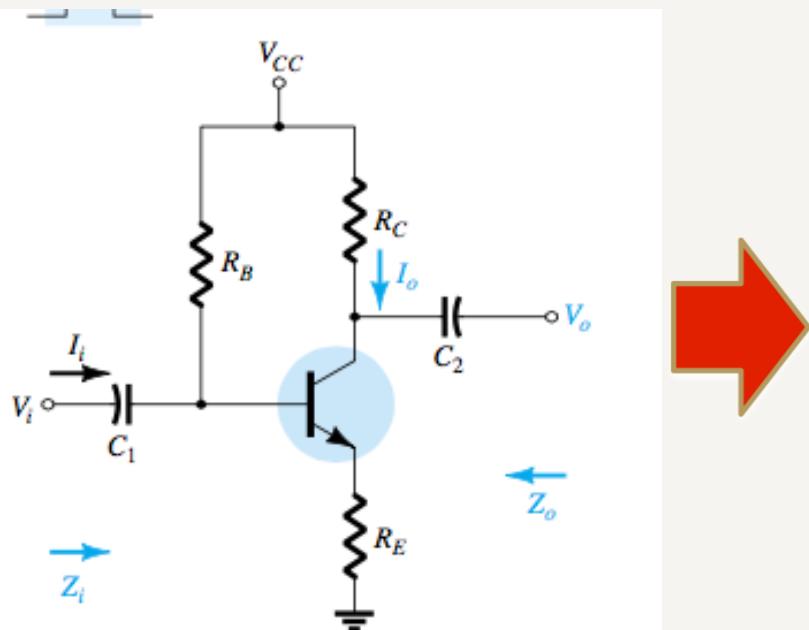
$$A_v = \frac{V_o}{V_i} = \frac{-R_C \parallel r_o}{r_e}$$

$$A_v = \frac{V_o}{V_i} \cong -\frac{R_C}{r_e} \Big|_{r_o \geq 10R_C}$$



BJT Transistors

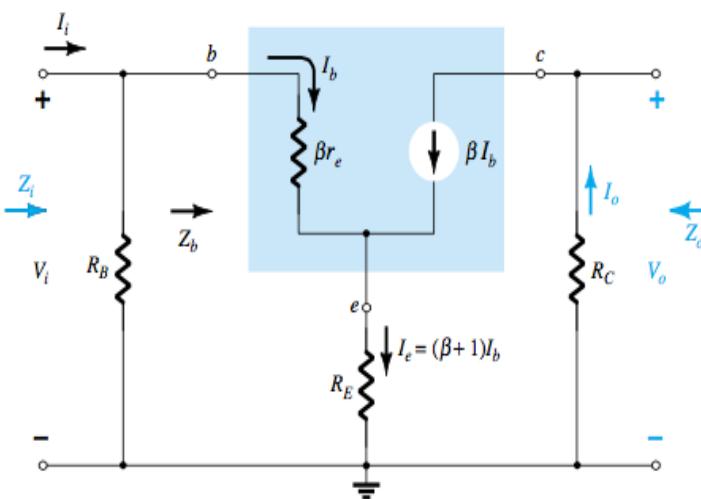
AC Analysis: CE EMITTER-BIAS CONFIGURATION





BJT Transistors

AC Analysis: CE EMITTER-BIAS CONFIGURATION



$$Z_b = \beta r_e + (\beta + 1)R_E$$

$$Z_b \cong \beta(r_e + R_E)$$

$$Z_i = R_B \parallel Z_b$$

$$Z_o = R_C$$

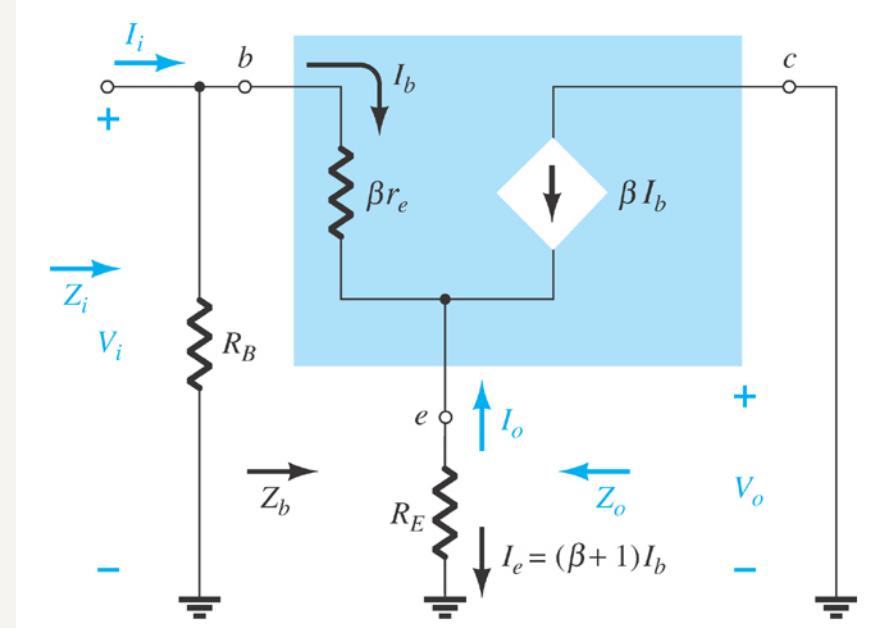
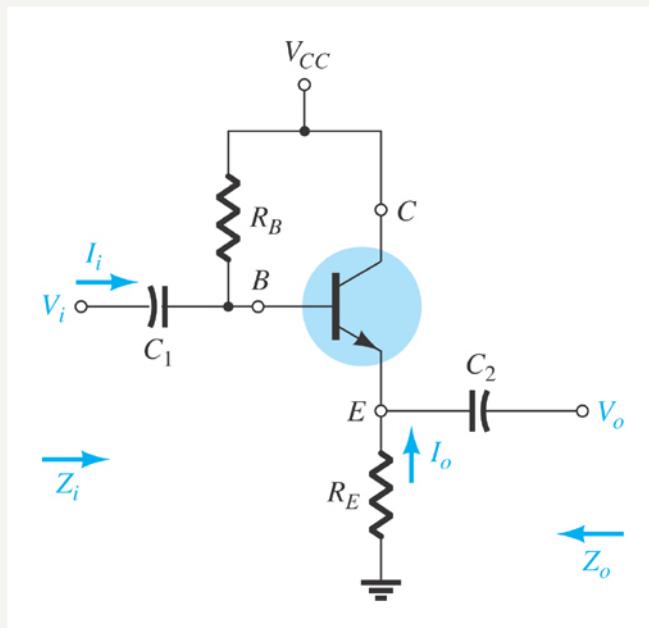
$$A_v = \frac{V_o}{V_i} = -\frac{\beta R_C}{Z_b}$$

$$A_i = -A_v \frac{Z_i}{R_C}$$



BJT Transistors

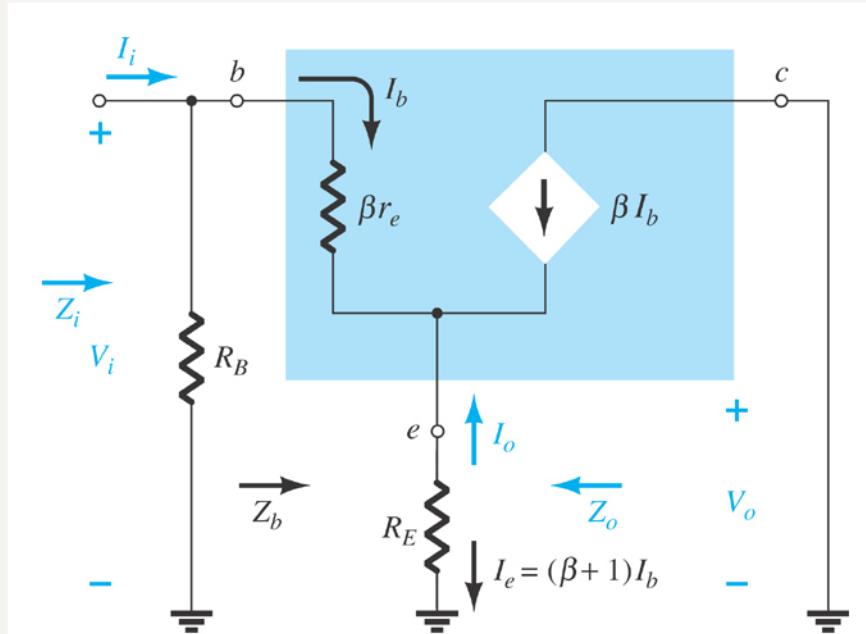
AC Analysis: Emitter follower (common collector)





BJT Transistors

AC Analysis: Emitter follower (common collector)



$$Z_i = R_B \parallel r_e$$

$$Z_b \cong \beta R_E$$

$$Z_o = R_E \parallel r_e$$

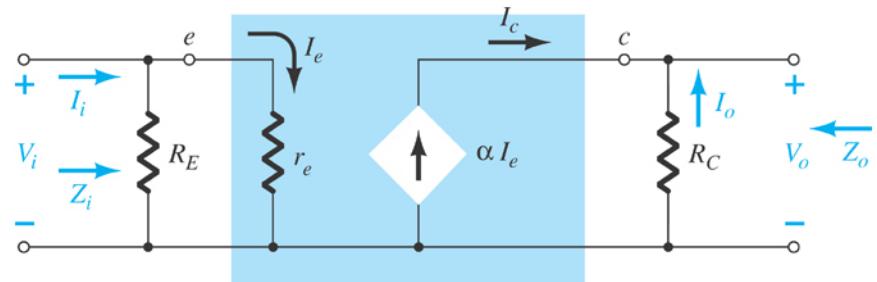
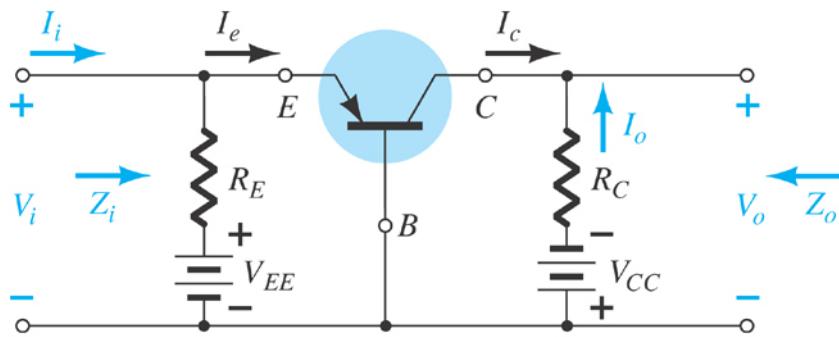
$$A_v = \frac{V_o}{V_i} = \frac{R_E}{R_E + r_e}$$

$$A_i = -A_v \frac{Z_i}{R_E}$$



BJT Transistors

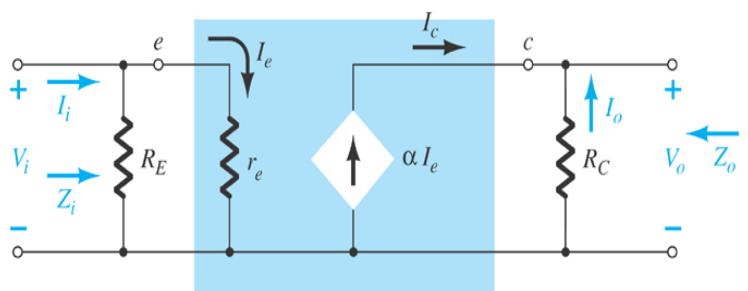
AC Analysis: Common Base





BJT Transistors

AC Analysis: Common Base



$$Z_i = R_E \parallel r_e$$

$$Z_o = R_C$$

$$A_v = \frac{V_o}{V_i} = \frac{\alpha R_C}{r_e} \cong \frac{R_C}{r_e}$$

$$A_i = \frac{I_o}{I_i} = -\alpha \cong -1$$



EEC2146: Electronic Circuits and Measurements

Questions